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Notes on the Physical Geography of the Bhawulpore State

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but although no water was found, Mr. Forrest felt every confidence in its existence.

On the 13th October, after a fatiguing journey of 17 days, they reached the coast at Thomas River; the bivouac of Mr. J. Forrest in 1870, when on his way from Perth to Eucla and Adelaide. From here they commenced their homeward route westward along the coast as far as longitude 120° E., and reached York on November 18th, after an absence of 100 days.

Mr. Forrest speaks in the highest terms of the members of the expedition; some portions of the journey being performed under most trying circumstances, the party on one occasion having spent two whole days and nights without closing their eyes, and walking a great part of the way.

XV.—*Notes on the Physical Geography of the Bhawulpore State.*

By J. W. BARNES, F.R.G.S., Superintendent of Irrigation.
January 15th, 1872.

IN the year 1869, the Supreme Government of India called on Major Minchin, the Political Agent and Superintendent, for information regarding the desert of this State, which led me to despatch a party of surveyors, who were employed for some months under my orders, taking a series of levels, which, when completed, were submitted to Government with the Report and maps, copies of which I now forward—the main object of this survey having been to search out this comparatively “terra incognita,” to ascertain its capabilities for agricultural purposes, and also the practicability of irrigating the same from the Sutledge River.

When the Report in question was prepared, my acquaintance with this part of India was very limited, but having now spent three years in Bhawulpore, and my official duties having given me opportunities of greatly extending my knowledge of this part of the country, (with the Political Agent's permission) I have much pleasure in placing at the disposal of the Royal Geographical Society some addition to my Desert Report.

A further study of this part of the Punjab has in nowise altered, but rather confirmed, my opinion that at some period the Bangur* land within this State had a settled agricultural population.

* “Bangur” is an Indian term, applied to alluvial formations whose surface is now considerably higher in level than the valleys of the rivers adjoining it, and was formed probably under circumstances somewhat analogous to the American Prairies.

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Map of the
BHAWULPORE STATE
 (PUNJAB)

to accompany the Paper by J. W. Barns, Esq^{re} F.G.S.

English Miles
 10 20 30 40 50 60 70 80

Geographical Miles
 10 20 30 40 50 60 70 80

30

29

28

Reference.

- Reference.
A A A	Line of ancient irrigating channel called Trewana.
B B B	Apparent continuation of the Trewana to a point near Roopur.
C C C	Line which may probably be found suitable for feeding Hukrah from the Sutlej.
D D D	Canal of Mirza Kunder.
*****	Railway constructing.

(PUNJAB)

English Miles

Geographical Miles

TATE

ns. Esq.^r F.G.S.

The fact of the River Sutledge flowing within a defined valley of its own, bounded on either side by high lands, many feet above its level, as shown by the section taken, precludes, in my opinion, the idea of this "Bangur" land having been watered therefrom.

There is moreover no room for supposing that the rainfall has ever greatly exceeded the average of the present day (which is about six inches per annum), a quantity altogether inadequate, in this thirsty land, for the growth of crops, except on a very limited scale; therefore, as there are only a few traces of wells for purposes of irrigation (if we accept it as a fact that this tract of country ever was cultivated to any large extent), there would appear to be ample room for believing that the waters of the "Ghuggur" River extended much lower, on their passage to the sea, than is at present the case, and that they were utilized for its irrigation.

Every part of this central tract called "Bangur" bears proof on its surface, that at some former period there must have been large areas of it flooded with fresh water for a long succession of years: not in the fitful manner of the Punjab rivers, where land becomes flooded from some sudden rise (in this case water rapidly drains off, on the river subsiding), but in that steady quiet manner, as is the case where there is rice-cultivation on a large scale; water used in irrigating this crop, owing to its slackened velocity, leaves a deposit of fine clay, free from silt, and gradually forms a surface as level as a billiard-table.

It is under conditions similar to the above, that the class of Testaceous Molluscs, so common to our tropical fresh-water lakes, is generated, and the presence of these shells on the "Bangur" lands seems to offer an indisputable proof of the argument adduced.

There are so many important and peculiar features connected with the present and past state of the "Ghuggur" River, that I trust, in my desire to give the opinion I have ventured to offer on this interesting subject greater weight, I may be pardoned for lengthening this paper by quoting extracts from authorities on the matter.

I find, in Thornton's Gazetteer, the "Ghuggur" is referred to "as flowing" through a level shallow valley, "about 29" miles wide, beyond the point where it enters "Sirhind;" it is afterwards joined by the "Markunda"* and "Sursoota," flowing down the same valley, which in time of inundation is deluged with water, forming a close net-work of streams, and sometimes causing the three rivers to coalesce in one great stream.

* Query, is not this the "Mirzakoonda"—a natural channel with an artificial head?

From the same authority I learn, that, having received the "Sursoota" and some streams of less importance, it passes into the British District of "Hurreeanah," and subsequently into that of "Blutteana;" it then crosses the Bikaneer frontier, and at a point about 22 miles south-east of "Bhutneer" is joined by its last feeder, the "Chittung," the bed of which receives the water of the "Hansi" branch of the "Jumna" Canal. The whole of the streams united, are said to have reached the Sutledge at a point 20 miles north-east of Bhawulpore; the country, though now quite barren and depopulated, abounds in ruins, the evidence of former prosperity.

Again, under the article "Sirhind," Thornton says, "the country between the "Jumna" and "Sutledge" is traversed by about a dozen considerable torrents, which generally communicate with each other during the season of inundation; that from near "Thanesur" to "Kouaheree," the whole tract of country (with the exception of village sites) is liable to inundation. The inhabitants avail themselves largely of the inundation for rice cultivation, but the spring crops are irrigated by wells. The slope and evenness of the country are calculated to favour even the rudest attempts to divert the streams from their original beds; the same circumstances would also render it easy, were it desirable, to confine them again to one or two principal channels.

Thornton also mentions, that, in the reign of Feroz Tagluk, "Tartar" king of Delhi, who ascended the throne in 1351, a portion of the water of the "Jumna" River was diverted into several of the torrents before referred to; and, after passing Hansi and Hissar, a natural channel conveyed the redundant waters westward until lost in the lands of Bikaneer, or probably in cases of very great floods discharged into the Ghuggur and ultimately into the Sutledge.

Turning to more recent information on the subject, Colonel Crofton, R.E., in his Report on the Sutledge Canal project, says, "between the Chituny and the Sutledge, numerous drainage channels intersect the country, some of which from their size have been rivers carrying large volumes of water in bygone ages, though now dry, except during periods of heavy rains. How and when the supply of water was discontinued, have long been and are still disputed questions; whatever the cause of the desiccation may have been, there is now a perennial stream in very few of these channels.

This desiccation opens out a very important field for inquiry as to what physical changes have taken place to have brought it about; the question is moreover full of interest in the present day, when the irrigation of tracts of land, so called desert from want of sufficient rainfall, engrosses so much attention.

Looking at the map, it will be observed that the "Ghuggur" and its tributaries are the natural drainage channels for the area, comprised east of a line drawn north and south through "Ferozepore," and bounded on one side by the Sutledge and the sub-Himalayas, and on the other by the River "Jumna."

These channels all converge at a point in lat. $29^{\circ} 14' N.$ and long. $73^{\circ} 08' E.$, and thenceforward a well-defined channel exists all the way to the sea; it being known as far as "Sinde" by the name of Hukra or "Wahind" (the literal meaning of the latter being the bed of a stream). In its course through Sinde it is known as the Eastern "Narra," and is the same channel into which Col. Fife, R.E., has thrown a feeder at "Arore," which irrigates that portion of the continuation of the Desert beyond Bhawalpore on the eastern border of Sinde.

As regards the portion of the so-called Desert, within the British territory eastward of Bikaner and Bhawalpore boundaries, the Punjab Government have arranged to irrigate it by a series of canals, drawn from the Sutledge at Roopur.

When these works shall have been completed, there will be an intervening portion of about 400 miles in length, only awaiting the time when a supply of water, suited to its area, shall be thrown into its deserted channels, to restore it to prosperity.

The Sutledge River, when in flood, carries a volume of water far in excess of 100,000 cubic feet per second, a large portion of which at present runs waste to the sea: the dry bed of the "Hukra" or "Wahind," on the other hand, is capable of taking about half of it;—what is more natural than that a junction should be made between the two? *

The most economical and suitable line for such a junction would probably be that from Ferozepore to "Abohar" on one of the tributaries of the Hukra in lat. $30^{\circ} 12' N.$ and long. $74^{\circ} 34' E.$, and is marked on the map by a dotted line, C C.

Other lines might, of course, suggest themselves, and the best be selected after suitable inquiry. I mention Ferozepore as one point, because a masonry dam across the River "Sutledge" at that point, is in contemplation by the Punjab Government, and it does not appear likely to interfere with the irrigation scheme, having its source at "Roopur," as before referred to.

The most natural would appear to be to follow the line of the "Mirza Koondees" Canal near Roopur; but I believe the depth of cutting is there very great, and it might interfere with Col. Crofton's Sutledge Canal Scheme.

* The discharge of the Sutledge at the period of its highest flood, in season 1871, was 208,000 cubic feet per second, as ascertained by Mr. Collett, Superintending Engineer of Indus Valley State Railway.

The "Jumna" River carries during flood about three or four times more water than the Sutledge, most of which also runs waste to the sea. We have proof that, at some former period, the water of the Jumna was led into this desert tract, and, therefore, what has been before accomplished on a small scale, could as surely be effected on a much larger one; but the distance appears to be a drawback to this scheme—it would, however, be something to resort to if anything interfered with the Sutledge scheme.

I believe, without doubt, that there would be no difficulty in carrying out either of these schemes. Like all large works, it is simply a question of cost and labour; but it would create so much wealth as to leave but little fear of its not returning ample compensation for the outlay incurred, if carried out on a scale sufficiently large, and commensurate with the interests involved.

It results from a tabulation of the surface level of the Sutledge, daily for one year, that for six months in the year, viz., from the middle of October to the middle of April, the flow of the river is very uniform; and this flow, which is assumed at 5000 or 6000 cubic feet per second, will be mostly absorbed by the large and important irrigational works in progress and projected by the Punjab Government.

Between April and October, the melting of the snow on the Himalaya Mountains, and subsequently the heavy monsoon rain and the drainage therefrom, help to swell this river. It is the flood portion of this supply, at present not utilized, which would be available to be drawn off, if the scheme I have referred to is ever taken in hand.

Long ranges of sand-hills within the Desert tract offer great facilities for the storage of surplus water, for use during the season when the river is low, which, of course, would add materially to the value of the project.

Turning from the Desert or "Bangur" towards the river border of the State, we find the alluvial tract intervening (which in Indian phraseology is called "Khadur" * and which is the actual valley of the rivers flowing through it), more or less intersected by canals, according as the irrigation in any one part of the State has been more or less developed.

From the sketch map of the Bhawalpore State, accompanying this Memorandum, it will be learnt that it possesses a river border of nearly 300 miles, of which 180 are on the

* Khadur is an Indian term applied to the land within the limits of the actual valley of a river, and, being formed by deposit from the overflow, marks the height of the highest flood to which the river has ever been subject. It is considerably lower in level than the "Bangur" land, which bounds it on either side.

Sutledge River, 40 miles on the Chenab, and about 70 on the Indus.

The rainfall does not exceed six inches per annum ; but so uncertain is it, and so parched is the ground on which it falls, that, but for irrigation, the whole State (with the exception of well-cultivation and the land submerged by the rivers during floods) would be reduced to a desert, and therefore it is only in a country of this kind that the blessings of irrigation can be properly understood and appreciated.

On the three rivers, collectively, there are 45 canals of various sizes led off for irrigation, not including any below 10 feet bottom breadth. Amongst the largest we have one on the Sutledge, 106 miles long (referred to hereafter), and on the Chenab River there are two canals, each 45 miles in length, 80 feet broad, and 11 feet deep during floods ; the other canals vary from 60 feet in breadth to 25 feet, and are from 40 to 20 miles in length. The aggregate length of the main channels is about 860 miles,—the branches from these aggregate nearly 500 miles,—and there are about 2000 cultivators' ducts (for leading water on to the different estates), which aggregate nearly 3000 miles in length.

Many of these canals were in existence long before the State came under British management, but were much neglected under native rule ; and it was left to Major Minchin to improve this great branch of the administration, which gives plenty to the people and wealth to the State, and to exemplify how rapidly the latent resources of a neglected district can become developed under a judicious and economical administration. There is the broad fact that, within the space of five years, the revenue of this State has increased from 100,000*l.* to 200,000*l.* per annum,* and Major Minchin contemplates realizing a maximum of 300,000*l.* per annum, by the time H.H. the young Nawab is of age, nine years hence. The population is estimated at 473,000, which shows a taxation of nearly 8*s.* 6*d.* per head.

Altogether these canals combined draw off from the rivers a quantity of water which I estimate roughly at 20,000 cubic feet per second during the height of floods, and a mean discharge, during the five months the canals are flowing, of nearly half that quantity. This large volume of water is nearly all used up in irrigation ; not a drop returns to either of the three rivers, and it is drawn from them in the following proportions :—From the Sutledge, 10,119 feet per second ; from the Chenab, 6477 ; and from the Indus, 3405.

* Of this sum from 40,000*l.* to 50,000*l.* is spent yearly in irrigation improvements alone, and 15,000*l.* to 20,000*l.* on ordinary public works, and, after paying the above and the expenses of administration, a good surplus is funded.

The above quantities are approximative only; we have not yet completed arrangements for accurately gauging the discharge of each canal, but when we consider that the estimated mean discharge of the season, viz. 10,000 cubic feet per second, equals 13 times the ordinary summer flow of the Thames at Staines, it will suffice to give an idea of the scale on which irrigation is carried on here, and the wealth thus created, seeing that each cubic foot per second irrigates from 20 to 50 acres, according to the economy exercised in its distribution.

The irrigation in that portion of the State east of Khyrpore* city seems to have been neglected for many years, until resuscitated by Major Minchin, although we find traces of a very extensive system of irrigation in bygone ages, which must have been in disuse for a very long period, as even tradition here gives no clue to the period either when these channels were dug or even in use.

The winding channels there shown, as compared with many works of the present day, are on a very large scale; and when it is understood that some of these ancient channels, after centuries of silting and disuse, are still from 100 to 200 feet broad, and 10 or 12 feet deep in places, it serves as a convincing proof that the ancients must have brought great resources to bear on the execution of their public works, and takes us back to an age possibly coeval with that in which similar works in Mesopotamia were projected, and which are so ably described in the Society's 'Proceedings' for 1867.

The main channel, in my opinion, had its source in the hill streams near Roopur; at any rate, the Punjab maps show traces of it here and there, even east of Loodeanah.

As a commencement of the resuscitation of the prosperity of the eastern district of the State, Major Minchin has already dug one entirely new canal (called the Fordwah), 106 miles in length, 60 feet broad, and 12 feet deep, which draws 2000 cubic feet per second from the Sutledge when in flood: the whole of this water is utilised in irrigating some 32,500 acres of land, and so great is the demand for water that we are constantly besieged by the cultivators to give them more.

Under the auspices of Captain Gray, officiating Political Agent, important irrigation works are this year in progress to meet their wants; and, in addition to two branch canals from the Fordwah, and numerous cultivators' ducts, we are trying to turn the long disused circuitous old channel, referred to previously, to some account.

Some few miles from the Fordwah head, a new city has been

* Lat. $29^{\circ} 35' N.$, long. $72^{\circ} 17' E.$

built within the last three years, and in compliment to its founder, Major Minchin, it is called "Minchinabad." * Latitude $30^{\circ} 11' N.$; longitude $73^{\circ} 37' E.$

Strange as it may seem, that with three rivers such as the Sutledge, Chenab, and Indus, which at all times have a supply of water for navigation by boats of light draught, none of these canals should be perennial, yet such really is the case. As it is difficult to realise the fact, by contrast with any of our European canals, a few words in explanation of this apparent anomaly may not be out of place:—

On the first glance at the cross sections of the country which I have drawn, nothing would appear simpler or easier than to construct canals which should run for ever; but, on the Punjab rivers, nearly all our canals have their sources in the alluvial soil, below the point where the river has neither rock nor boulders to protect its banks and bed, and the water flowing in them is so laden with silt, that a large portion thereof is lodged within the bed of every canal for the first few miles from the point where it leaves the river; and when the annual floods subside in October, it is generally found that the head of the canal is so choked up as to have ceased flowing.

From the experiments made by General Tremeneheere, C.B., as recorded in the Society's 'Proceedings' † for 1857, the Indus water appears to contain an average of 25 parts in 10,000 by weight of silt, and from those data it follows that as silt weighs somewhere about 160 lb. per cubic foot, a mean volume of 10,000 cubic feet per second will carry with it during the five months that the canals are flowing a quantity represented by a mound of earth 1 square mile in area and 4 feet 6 inches in depth.

The silt thus borne along by the water contains about one-half clay, and one-half very fine sand and mica; and as it is this latter which is chiefly deposited in our canals, it follows that in the irrigational channels of this State, this half amounts to a total of 2,343,600 cubic yards, which has to be annually cleared out therefrom by manual labour to prevent the canals being entirely choked up; thus it will easily be seen how neglect for two or three years would very soon render them useless.

A steam dredge is expected very soon to arrive from England, fitted in such a manner as to raise the silt sufficiently high to deposit it on the spoil-banks of a canal, the lift from bed to top of spoil-bank being from 15 to 20 feet.

As compared with the large quantity of silt we have to deal with, the services of one dredge for this purpose will scarcely be felt; and it is problematical whether in dry excavation the cost of raising silt by machinery can compete with manual labour at rates varying from 8d. to 1s. per day; but in cases often occurring, where the river forms a bar between the main stream and the head of a canal, where the material to be removed is a quicksand, and manual labour can with difficulty be applied, it will be invaluable.

In this state all canals are looked on as a sort of co-partnership between the State and landowners, who are here called Zemindars, the State giving large sums in aid of all new works of any importance. The canals are kept in order at the cost of the landowners, under arrangements between them and the cultivators; but in exceptional cases, when there is an unusual deposit of silt, the State gives grants in aid towards the cost of clearance.

To effect this clearance of silt, about 10,000 men are generally employed

* The termination "Abad" is a Persian word, meaning "flourishing"—"prosperous."

† Vol. xi. p. 22.

for a space of three months after the summer crops are harvested; and hence, from the falling of the river in October until the completion of the clearance, which is generally finished by the end of March or April, no water is admitted into any of the canals on that account.

Whilst, as I have explained, one half of the water-borne silt has to be cleared out of the beds of the canals, the other half, which is carried in by the water, in suspension, is eventually deposited on the land irrigated; thus, whilst yearly increasing the depth of soil, it is likewise fertilising the land, inasmuch as it contains a great deal of organic matter.

Enormous as is the quantity of silt carried inland by the canals, it is but infinitesimal as compared with what is deposited by the rivers themselves when flowing over or submerging low lands on their banks. Instances are not rare where, in the space of three years, vast changes take place in the course of a river, resulting, perhaps, in its eating away one bank for a length of 5 miles, and a breadth of 2 or 3 miles, sweeping away villages, wells, gardens, and trees, in its headlong course, and in the part where the river before flowed to a depth of 15 or 20 feet, silting it up entirely, consequently forming new land.

This shows how uncertain all irrigation arrangements must be on rivers which are subject to such vicissitudes, and how serious it becomes when, in making some sudden change, it throws up a sand-bank of a mile in breadth, and sometimes many in length, between the flowing stream and head of a canal, leaving the bed of the latter dry: this actually occurred last year with one of our large canals, and occasioned a failure of about half the area of crops cultivated on it, which perished from want of the final watering.

The bed of the Sutledge, for a depth of 80 feet, has been proved to consist of very finely comminuted micaceous sand, almost entirely free from earthy particles, and its banks, below low-water level, are mostly composed of the same yielding material. A current with a velocity of only 2 feet per second, acts freely on it; and as the velocity of the Sutledge, wherever its current sets, is as high as from 6 to 8 feet per second, we have thus an explanation of the causes operating in the devastation of its banks, and also a satisfactory reason why its waters are so largely charged with silt. So incessantly is erosion going on, that within the limits of its valley every part seems to have undergone the process of having, at some time or other, been eaten away by the river, and re-formed again; hence it is a rare thing to see either any very old building or a tree of great age on its banks.

As far as I can judge, the sand-hills referred to in my first report as forming the boundary between the Khadur and Bangur lands, seem to mark the limit beyond which its erosion on the south side has never extended, and I believe at the present day its meanderings are confined within a breadth of 10 miles.

The Sutledge seldom exceeds 20 feet in its deepest part, and

during its highest flood does not rise more than 10 feet above the lowest surface level.

The rise of the Chenab River is generally 2 feet more than the Sutledge, and that of the Indus about $1\frac{1}{2}$ foot more than the Chenab. The depth of these two rivers during flood is often from 30 to 40 feet in places.

As the canals flow only for five or at most six months in the year, during the hot season, when the rivers are in flood, the crops grown during that season are the only ones which have the benefit of direct canal irrigation: on the other hand, a very large area of wheat and pulses is cultivated in the winter on land which has had a heavy flooding by canal water or river overflow; the crops being matured in the spring by irrigation from wells, wherever the depth of spring-water level below the ground surface is so low as to afford no nourishment to the roots by capillary attraction.

As remarked in my first Report, the spring water on the Sutledge lands is from 20 to 30 feet below the surface, and here, wherever wheat crops are grown (except on lands submerged by the river's overflow) they generally get three to six waterings during the season from well-water, according as the land may have had a flooding from canal-water or not. On the Chenab and the Indus lands the spring-water level is generally much nearer the surface, and, moreover, as the flooded soil is more retentive of moisture, watering wheat-crops from the wells is not so universal—indeed, it is the exception rather than the rule.

In percolating through the sand, the well-water evidently takes up a very appreciable quantity of sulphate of soda, and is likewise in places impregnated with sulphuretted hydrogen.

The daily use of water containing these ingredients is supposed to induce a tendency to scurvy, which, amongst the natives, is counteracted in some degree by their partaking largely of sour buttermilk. The Nawab's household, as a rule, send to the river for their drinking-water, and, when possible, the European families adopt this course: the Civil Surgeon has impressed on us the advantage of having the well-water boiled before drinking it or using it for culinary purposes.

In General Tremenneere's paper on the lower portion of the Indus,* reference is made to the inundations which every now and then occur. In contrast with some other parts of the world, where severe inundations bring in their train destruction of life and property, and are considered a calamity, here, on the other hand, as regards the inundations to which portions of this State

* Royal Geographical Society's 'Journal,' vol. xxxvii. p. 69.

are liable from overflow of the rivers bordering it, it is looked on as a blessing; and although, occasionally, portions of the summer crops sown within its reach get destroyed, for one acre of such there are perhaps fifty acres of otherwise waste land submerged, and therefore susceptible of cultivation.

After the floods have subsided, the land is at once ploughed up, and the surface being well pulverized, in order to prevent as far as possible the escape of moisture by evaporation, it remains fallow until November.

Wheat, barley, and the other cereals, and oil seeds of temperate climates, are then drilled in, and (excepting those well-lands whose surface is generally too high in level to acquire a thorough saturation during the flood) crops are produced without any subsequent watering, depending for their sustenance during growth on the moisture which the soil has imbibed during the floods, and the dews that are precipitated by its gradual evaporation and subsequent condensation during the cold nights. There are low portions along the banks of the rivers, which, during every flood, get regularly submerged, and, where cultivated, bear crops of pulses and wheat. But the inundations referred to by General Tremenhare are of far greater importance than the above, and are, moreover, exceptional, inasmuch as two simultaneous conditions are necessary to bring them about: 1st, continuous heavy rains in the watersheds of the three rivers at one and the same time; and 2ndly, the set of the river on the left bank; this latter alone on the Indus and Chenab making sometimes a difference of 2 feet in the height to which the water rises under conditions in other respects similar.

A reference to the sections taken across the State, from Bahadur on the Indus to Kundairah on the Hukra, will show how certain, and at the same time how natural, it is for this crest of the inundation (if not checked) to flow down over the gentle slope of the country in from its banks, whenever the floods rise sufficiently above their ordinary level to overflow the bank. The land submerged by this overflow is generally of the richest description, inasmuch as every successive flooding leaves a rich deposit of fertilising silt, and as the floods are not annual, the fallowing of the land between the intervals of a flood's advent, adds to the fertility of the soil. In thus escaping over the high bank during a succession of years, each river forms a glacis for itself, and in course of time even its bed becomes higher in level than the surface of the ground some miles inland, and it is this peculiarity which gives such facilities for taking off irrigation canals. Not only is this a normal condition with each river, but every channel of any description (where its waters are not prevented from overflowing its banks)

forms a glacis for itself, and, as a rule, the highest ground is always to be found on the banks of a channel whether it be in use or deserted. This reverses, of course, the natural arrangement which we observe in the valleys of most of our rivers at home, where all surplus water in the valleys finds its way into the river, instead of, as here, the river water escaping into the valleys, never again to return.

It is the silt with which the water is so heavily charged that causes this. The moment the overflowing water escapes from the river, the decrease in the velocity of the running water causes an immediate deposit, first of the heavier portions, and so on until after proceeding a short distance none but the finest particles are held in suspension.

I have noted in the cross sections the surface level of spring-water in various places, and from the observations recorded it will be seen that the greater the distance any well may be from the river, so is the surface level of its water lowered, proving, of course, that as there is no surface drainage percolating into the soil, there must always be a subterranean drain inland from the river along its whole course. From this we may assume, what I believe must really be the case, that the further rivers of this class run, so much must their waters become diminished beyond the point where they possess no feeders. As a rule, I think we may accept this with regard to all the Punjab rivers except the Indus; though it is only, I believe, during rains that that river receives any addition to its volume by drainage from the "Suliman" and subsidiary ranges.

Reverting to the subject of the periodical overflows, I have just been put in possession of a report of the action of the same in the lower portion of the Bhawalpore State during the past season, which was one of exceptionally heavy rains in the watersheds of the rivers draining the Himalayas.

Three large overflows occurred: one above the junction of the Sutledge and Chenab near Ooch; one near the junction of Chenab with the Indus; and a third on the Indus just above Subzulkote. I have sketched their courses on the tracing now forwarded.

These overflows commenced at the beginning of August, and lasted throughout the month. The one east of Ooch is described as having been in places some miles in breadth and ranged from 1 to 4 or 5 feet deep. It extended s.s.w. to Khanpore, a distance of nearly 50 miles.

The next overflow which took place was in the neighbourhood of and above the junction of Chenab and Indus, and extended for a distance of 18 miles; it spread over the country for a breadth of from 2 to 10 miles. On its western side the flow was checked by the embankment of the "Kubeera" Canal, but as was

the case with the overflow from Ooch, the water was kept sufficiently under control to guard against damage to existing cultivation, and likewise flooded many miles of country for winter crops.

The third overflow, which was from the Indus near the southwestern boundary of the State, was of far greater extent than the two just described, and appears to have overflowed the river bank over a distance of 15 miles. It left the river above Subzulkote, and after crossing a canal called the Subzulwah, passed into the Sind district. How far this extended I have no account of. As regards the other two, it will be seen that, great as was the volume, all was absorbed within the State.

I am not prepared with data to show the quantity of water thus introduced into the country, which, it must be observed, was in addition to the canal supply, which latter a very high and exceptional inundation raised much above the average. I should suppose, however, that the volume of these combined floods could not have been less than 30,000 cubic feet per second at highest level of overflow.

When an inundation of this kind does happen, flowing as it does for miles over ground of which portions are under crops, we may well suppose how disastrous would be the result if left entirely uncontrolled, and at the same time what anxiety must prevail to get as much benefit out of such a godsend as possible, by diverting its flow over land which may perhaps have lain fallow ever since a similar flood of some years before. Accordingly, at such times, the whole agricultural community concerned, headed and aided by the presence of the Revenue and Irrigation Officers, assemble and unite in their efforts to control and guide the waters of the flood in their onward course; and so thoroughly is the thing understood by the people here, and, as regards the flood in question, so heartily did all co-operate in the one mutual object, that but a very small percentage of the standing crops were injured, whilst many thousand acres of most luxuriant wheat now gladden the eye on land which, but for the flood, would have remained uncultivated.

This short account of an occurrence by which a store of moisture is periodically bestowed on this thirsty land, and the almost incredible manner in which such enormous volumes of water, equalling some rivers, are absorbed and utilized, will help more than aught else to demonstrate how vast and, as one may say, unlimited are the requirements of countries situated, as is this State, in a comparatively rainless region. We could not have a clearer proof of the wisdom and beneficence of Providence than in having placed on the border of this rainless and arid land three such rivers as the Sutledge, Chenab, and

Indus, which are fed so bountifully from the stores of wealth laid up during the cold weather on the far-off Himalaya Mountains, and, by the melting of the snow supplemented by the subsequent monsoon rains, having brought it within reach of the same at the very time it is so much needed.

NOTES ON THE CLIMATE, AGRICULTURE, &c., OF THE BHAWUL-
PORE STATE.

The Bhawulpore State, though it has an extra-tropical climate, has, owing to the rarity of its atmosphere (caused by deficiency of rain), a very high summer temperature, and there are, I should suppose, few countries of its latitude which have such a continuance of hot weather. The severest part of this season is from the end of April until the middle or end of June, during which months the mean temperature in the shade is 103° ; not only is the heat of the sun very great, but the air is dry, and the wind is almost fiery, and, during these months, the growth of vegetation is scarcely perceptible. But with the bursting of the south-west monsoon comes a change: gradually the intense heat of the two previous months is softened down by clouds, the mean temperature falls to about 95° in the shade, and there is a perceptible degree of moisture in the air. The scorched grass and trees respond to the change by putting forth young shoots, and with only an inch of rainfall the whole country looks for a time quite green and fresh.

This latter season is a busy time for the agriculturist. The same cause which has supplied moisture to the atmosphere, has also filled the rivers (and therefore the canals) with water, and, at this time of the year, cotton, rice, indigo, and all the various grains, &c., which are common to all tropical countries, are then put into the ground, and come to maturity in the autumn.

Indigo is grown here on a considerable scale, but soil and climate are particularly suited to it. This valuable plant, with a plentiful supply of water, sometimes attains the height of six or seven feet. The manufacture of the dye is carried on in a most primitive manner here: the whole cost of vats and implements for a field of 10 acres ranges from 5*l.* to 10*l.* sterling. In this dry climate the whole process is carried on in the open air, and, when ready for sale, it is in pieces of the size and shape of what is called in England "thumb-blue;" it acquires that peculiar shape from being taken up between the thumb, fore and middle fingers, when in a pasty state, to be laid out for drying. It contains more or less impurities (chiefly of clay), according to the care taken during the process of manufacture. It is nearly all purchased by the Cabul merchants at a price ranging

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generally from 10*l.* to 12*l.* per cwt., and doubtless finds its way into the markets of Central Asia.

Great as is the change from the scorching heat of May and June to the more genial but still tropical heat of July, yet greater is the change which November ushers in; after which a dry wind from the snowy ranges reduces the mean temperature to 60° or 65° with frosty nights, reminding one once more of our English climate without its rain.

After harvesting the summer crops, the ploughman has no rest, for now commences the season for putting in all the cereals, &c., which form the staple of our cultivation at home. Wheat crops miles in extent, without a fence or division to break their continuity, almost excite one's wonder at the means whereby such large areas can have been put under crop in a country not over-populated, and possessing no implement better than the rudest native plough made by the cultivator himself (very often out of the very commonest materials) by a couple of days' labour, and worked by a pair of small-sized bullocks not much larger than many a yearling at home.

The seed is drilled in. The implement (drawn by a pair of bullocks) consists simply of one upright hollow bamboo with a wooden cup on its top, and fixed on what may be called the rear of the ploughshare; and thus, as the plough is guided by the ploughman's left hand and makes its furrow, the seed is dropped in the cup with the right hand, and so becomes simultaneously covered up.

The ordinary produce of wheat is from 11 to 24 bushels (of 55 lbs. each) per acre.

Though wheat is the staple winter crop, many other things grown in temperate climates thrive during the cold season; fields of turnips for feeding the farmer's cattle are found around every homestead, and in the absence of our nourishing crops of grass and hay, young wheat is universally cut and given, in its green state, to horses during this season.

These winter crops are generally matured by the end of April, and their harvesting, thrashing, and winnowing occupy the cultivators until the season arrives for preparing the ground for the summer tillage.

With the exception of potatoes, which (if not artificially protected) suffer from the frost, all our English vegetables come to great perfection here: indeed, I have seen cauliflowers and lettuce in our station gardens at Bhawulpore as fine as some of those grown at home.

Gardens well stocked with fruit-trees abound in the outskirts of the Bhawulpore city, and at every town where His Highness the late Nawab usually halted on his hunting and shooting

excursions a garden is to be found. Whilst the mango-tree (where attention has been paid to its culture) grows to a large size, and produces a fruit of unrivalled flavour, which comes to maturity in the hot weather, there is sufficiently cold weather to enable the apple-tree to produce a small, though eatable, fruit, which ripens about the middle of April.

There are likewise numerous groves of orange-trees and pomegranates; the former attains sometimes a height of 12 feet, and produces fruit at the usual Christmas season. The fruit of the superior kind of pomegranate-trees is very fine, and is sometimes as much as 1 lb. in weight.

Peaches of a peculiar flat shape, but very small, with a faint attempt at the bloom so attractive in our English fruit, grow in abundance, but they lack that delicacy of flavour which we are accustomed to associate with this fruit in England.

We have also the date-palm, which is the one great type so common to all countries in the northern hemisphere possessing an arid climate, with extreme summer heat and a low winter temperature. The tree is found in all parts of the State, and is especially abundant in the neighbourhood of all villages where the early Mahomedan conquerors settled. It has occurred to me as probable that, even if the date-palm existed here before their arrival, the cultivation of a tree of such importance in their own country would most likely have received especial attention from them. We find as well the following fruit-trees in the gardens:—Lime, lemon, citron, mulberry, fig, ber (*Zizyphus Jujuba*), jamoo (*Jambosa vulgaris*), and grape-vines.

In a country like Bhawulpore, where scarcely anything grows without irrigation, either from the river, canals, or wells, it will not be surprising that there are no forests, and that timber trees are scarce.

The following is a list of such trees as do grow here:—Babool or keekur, *Acacia Arabica*; neem, *Azadirachta Indica*; poplar or bahn, *Populus Euphratica*; false blackwood or sheeshum, sissoo or talee, *Dalbergia Sheeshoo*; banian-tree, *Ficus Indica*; peepul, *Ficus religiosa*; biting peeloo, *Salvadora Persica*; leafless caper-bush or kirrier, *Capparis aphylla*; horseradish-tree, *Moringa pterygosperma*; mountain neem, *Melia Buckayen*; sweet peeloo, *Salvadora cleoides*; seriss, *Albizza Lebbek*; amultas, *Cassia fistula*; tree tamarisk or okah, *Tamarix articulata*; pilchee, *Tamarix deoca*; laee, *Tamarix Gallica*; thorn-tree, jhund, or khundee, *Prosopis spicigera*.

Except for a month or so after rain, or where the ground is either irrigated or receives an overflow from the river, this State is badly off for natural grasses, and there are none cultivated: hence the breed of horses, cattle, sheep, and goats is poor. The

two latter, indeed, live for a large portion of the year on the leaves of shrubs and trees, the branches of which are systematically lopped off by the shepherds of the flocks.

But when rain does fall, more especially in the desert, the whole surface, in a few days, is covered with vegetation; and so nutritious is it, that the milk acquires a delicious aroma and richness beyond conception, and cattle and sheep at that time get quite fat after feeding thereon for a couple of months.

But of all animals the camel is most at home in this arid country, where, whether on the sand-dunes of the desert or in the valleys of the rivers, and whether rain falls or not, this beast seems to thrive: the salsola and tamarisk plants and shrubs, of which there is such a variety, form his staple food, whilst at the same time the tender shoots of the acacia, or, indeed, nearly all the known timber-trees here, afford that change of diet which is, I believe, one of the great secrets in the successful rearing of these animals.

The whole of the region included in this and the neighbouring States is simply one vast breeding-ground for these animals: their selling price varies from 6*l.* to 20*l.*, according as they may be low or well bred.

In conclusion, it may be interesting to those unacquainted with this part of India to learn something about some of the people amongst whom the writer of this Paper is labouring, and I cannot do better than give a few extracts from Major Minchin's Reports on this State to the Punjab Government for 1867-68-69:—

“The earliest authentic account shows the Dadpotras * as settled at Shikarpore, in Sind, where they had dug canals from the Indus, and were in a very prosperous state. A dispute arising with the Governor of Sukkur about the payment of revenue, the Dadpotras marched in a body, two days' journey, into the desert. They were pursued by the Dooranee troops, and, being encumbered with their women and children, they adopted the desperate measure of killing them all, and then attacking the Dooranees. They routed them with great slaughter, but, being afraid to return to Shikarpore, they marched up the left bank of the Indus, and settled near ‘Allahabad,’† in this State. This was about ‘the year’ 1737. They divided what is now known as the Bhawalpore State amongst the chiefs of the tribes, and selected Bhawal Khan, of the Peerjani section, as the head chief, who then founded the city of Bhawalpore. A Belooch of the Goorgij tribe, who had accompanied him from Sind, was appointed his minister. This Belooch, during the rule of Bhawal Khan the Second, succeeded in gradually reducing the power of the other ‘Dadpotra’ chiefs, and made them accept their Jageers ‡ under Sumnud from the Nawab, whose Government was recognized by Timoor Shah, Emperor of Delhi, in 1789. In 1827, Bhawal Khan the Third succeeded him, and consolidated the State: all the Dadpotra chiefs acknowledging him as Nawab, and receiving their titles to their Jageers from him, on the condition of feudal service.

* The family of H.H. the Nawab—literally “the sons of David.”

† Lat. 28° 59' N., long. 70° 56' E.

‡ Jageer is the name of a rent-free grant of land, and is generally for life only.

"On the death of Bhawul Khan, his second son, at his desire, was made Nawab, but was deposed by a conspiracy on the part of the Dadpotra chiefs, headed by Akil Mahomed Khan Achrani, within four months of his accession, and his elder brother, Futteh Khan, became Nawab. On his death, in 1859, his son, Bhawul Khan the Fourth, succeeded him.

"'Father of the present Nawab.' Bhawul Khan the Fourth died suddenly in June, 1866. His son, Sadik Khan, was acknowledged as his successor by the British Government, the Commissioners of Mooltan being deputed to invest him with the customary insignia.

"Soon after this date, the Queen-Mother and principal members of the State applied to have the State taken under British protection during the minority of the young Nawab.

"The Zemindars (cultivators) are a quiet, peaceable race, and very amenable to control; they are excellent agriculturists, and very hard working. The dread of civil war alone disorganized them, and a settled Government is to them the greatest blessing. This is clearly shown by the energy with which they have come forward to carry out canal improvements: they are daunted by no difficulties.

"The description in Tacitus of the ancient Britons is peculiarly applicable to these people:—'They cheerfully bear the conscription (statute labour), the taxes and the burdens imposed on them, if there is no oppression.'

In a former Report I mentioned having discovered an old tower in the desert, about 18 miles south of Bhawulpore, in which we found an old plate with an inscription written in the old Sanskrit character.

This plate has been partially deciphered by Mr. Bayley, B.C.S., showing that it was a dedication of the vehar, or Buddhist Monastery of Dumane, for the benefit, religious, of sundry barbarously-named relatives of the Bhiskee, *i.e.* Bhikshee, or religious mendicant, in the Sumbut, or area, of King Kanishka, in the month of Daisiki. Mr. Bayley considers it valuable as confirming General Cunningham's surmise as to the use of Macedonian names of months, or, at least, attempts at them—the Daisiki being the equivalent of Dasmus.

It also confirms Sir H. Elliot's opinion that the Buddhist religion was the prevalent one in Sind when the Mahommedans first came in contact with Indian superstitions; and this would in some measure account for the retention of this name, "Soohi vehar," to the present time.

At page 406, volume i., note B, of Sir H. Elliot's 'History of India, as told by its own Historians,' it is related that Rai Sahasi XI. remitted certain taxes on condition that the people should raise six forts for him—at "Ooch," "Matela," "Scorai," "Mau," "Alor," and "Sewistan." Two of these forts, *viz.* "Ooch" and "Mau," are in this State.*

* "Ooch" is at the confluence of the Sutledge and Chenab. "Mau" is situated in lat. 28° 35' 0" N., long. 70° 24' 0" E. Matela is, I believe, on left bank of the Indus, in Sind, some miles below Subzulkote. "Alor" is near Roree, opposite Sukkur on the Indus, in Sind. Sewistan is the present Schwan, on right bank of Indus, in Sind.

At "Mau" there is a shrine which has been about 100 years in existence, and the tradition is that the old fort was then in the same state as it is now. The walls are very high and in wonderful preservation; and, if the conjecture is right that the passage in the Chachnama above-mentioned refers to these forts, they must be 1300 years old, as "Chach," who succeeded Sohas XI., ascended the throne of Sinde in Hijiri 10, corresponding to A.D. 594.

XVI.—*Notes of a Reconnaissance of the Anti-Libanus.* By RICHARD F. BURTON, F.R.G.S., and CHARLES F. TYRWHITT-DRAKE, F.R.G.S.

MANY readers, even professional geographers, will think that we are to pass over trodden ground, and that in describing the Anti-Libanus we can do nothing but fill up with details the broad outlines traced by predecessors. The contrary is positively the case. I expected great things from 'L'Anti-Liban, par Gérard de Rialle' ('Bulletin de la Société de Géographie,' tome xvi. 1868), and found that it treated of only the well-known lower altitudes well trodden by a host of travellers. Surprising as it may seem, it is still true that the best and most modern maps do not name a single valley north-east of Zebedání, nor a single summit, except the "Jebel el Halímeh," an utter misnomer. They show merely the long conventional caterpillar, flanked by the usual acidulated drops, and seamed with the normal cobweb of drainage: when they have disposed all this parallel with the Libanus, they have apparently done their duty. Thus they neglect to show, amongst other things, the important changes in the chain, whose northern half becomes exceptionally arid, whilst the southern is remarkably fertile. This is also true of the windward and seaward chain of Libanus, but to a lesser extent. The traveller in Syria and Palestine is also left in ignorance of the fact that the general aspect of the range is superior to that of the maritime Sierra, that the colouring of the rocks is richer, the forms are more picturesque—often, indeed, "weird, savage, grand, almost magnificent, like parts of Moab"—that the contrasts of shape and hue are sharper, and that the growth in places assumes the semblance of a thinned forest. Of the Anti-Libanus we may say, of the Libanus we may not, that "ravines of singular wildness and grandeur furrow the whole mountain-side, looking in many places like huge rents, whilst the views from the summits are far superior in extent of range and in variety of feature."